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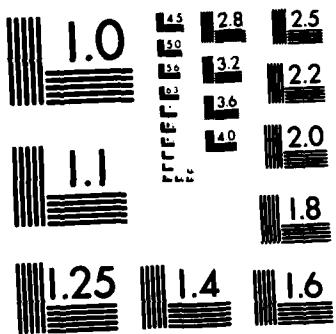
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ASYNCHRONOUS DISCRETE CONTROL OF CONTINUOUS PROCESSES

M.E. KALISKI AND T.L.JOHNSON

JULY, 1984 ANNUAL REPORT

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1. INTRODUCTION AND STATEMENT OF WORK

This report summarizes the research undertaken during the period from July 1, 1983 through June 30, 1984, the second year of a three-year research program entitled "Asynchronous Discrete Control of Continuous Processes".

The research during this second contract year continued to deal with the development of sound theoretical models for asynchronous systems. Two criteria served to shape the research pursued: the first, that the developed models extend and generalize our previously developed research for synchronous discrete control; the second, that the models explicitly address the question of how to incorporate system transition times into themselves. The following sections of this report concisely delineate this year's work.

Our original proposal for this research identified four general tasks of investigation:

(1.1) Analysis of Qualitative Properties of Asynchronous Hybrid Systems

(1.2) Acceptance and Control for Asynchronous Hybrid Systems

Chief, Technical Information Division



(1.3) Linguistic Approaches to Asynchronous Systems

(1.4) Application to Real-Time Multi-Tasking Systems; Stochastic Analysis

During this past year, as in our first year of funding, the emphasis has been on Tasks (1.1) and (1.2), which, to a large extent, are prerequisite to Tasks (1.3) and (1.4).

Various fundamental issues that have been uncovered have necessitated this continued emphasis. The research continued to involve a collaboration between Professor Kaliski of Northeastern University and Dr. T.L. Johnson of Bolt, Beranek and Newman, Inc. (Dr. Johnson is currently with General Electric Corporate Research and Development, Schenectady, NY). Dr. Johnson was responsible for Task 1.1; Professor Kaliski for Task 1.2.

2. RESEARCH PROGRESS

2.1 Analysis of Qualitative Properties of Asynchronous Hybrid Systems

The major activity of Dr. Johnson this past year has been the revision and extension of the paper entitled "Realization of Asynchronous Finite-State Machines," initially presented at the 22nd IEEE Conference on Decision and Control (December, 1983, pp.464-469), and included in our January, 1984 renewal proposal.

This work is almost complete, and will be submitted, in written form, for journal publication. The revision provides a proper mathematical setting for the topic and includes completed proofs of the main results. The essential conclusions are unchanged.

An invited paper entitled "Multitask Control of Distributed Processes" was presented at the same conference (pp.1128-1131). This paper extends earlier of Dr. Johnson work on representation of asynchronous multitasking systems. In principle, this model can now be converted to the more advanced representation developed in the paper on asynchronous state machines.

A Pascal simulation of the asynchronous finite-state realization proposed in the first paper has been partially completed and may be used to generate results as well for the revised paper version. Under separate (Army) sponsorship, a special case (linear single-input, single output, second order systems) of the discrete control algorithm initially described in the Ph.D. thesis of Wimpey (under support of this project) was implemented by Dr. Kaliski. Further testing of these results on design examples is anticipated in the near future.

2.2 Acceptance and Control for Asynchronous Hybrid Systems

Research has continued in two principal tracks this past year (by Dr. Kaliski). The first involves the continued investigation of the "extension problem" for finite state realizations of asynchronous coders. This problem, as detailed in our earlier annual reports and proposals, arises as a fundamental one in asynchronous coder design when the issue of explicitly including event times is pursued. The memorandum in Appendix 5.1 of our January 1984 renewal proposal ("Extensions of Partially-Specified Automata Including Time as an Input") details our work in this area, and we are currently working to combine the results of this memorandum with some of Wimpey's earlier work on synchronous coders to produce a definitive research paper on asynchronous (and synchronous) finitary coder design.

The second theme we have followed is the further exploring of the relationship between Dr. Kaliski's prior (unfunded) research in orbital behavior of non-linear discrete-time systems (with Q.L.Klein and S.Y.Kwankam) and characterizations of the input/output spaces of asynchronous coders. This has led to the acceptance of a paper at the

upcoming IEEE Decision and Control Conference and to some important insights into the role of orbital behavior models in characterizing coder behavior.

Note that these results form the underpinnings to the more general area of acceptor design and controller design. We need to understand from many different viewpoints what an asynchronous coder is and what it can do prior to understanding how to use it as either a transducer or a controller.

3. PUBLICATIONS

The following works have been published and/or submitted for publication during this past contract year. Copies of summaries of the second and third references below is are with this report; copies of the other articles have already been sent to AFSC.

Kaliski, M.E., "Extensions of Partially-Specified Automata Incorporating Time as an Input," Northeastern University Memorandum, September, 1983.

Kaliski, M.E., "On Realizations of Partially-Specified Input/ Output Maps by Finite Automata," 1984 ACM Computer Science Conference, Philadelphia, PA, February, 1984.

Kaliski, M.E. and Kwankam, S.Y., "Asynchronous Real-Time Coders in the Discrete Control Environment; Generative Models for Input/Output Spaces," to be presented at 23rd IEEE Conference on Decision and Control, Las Vegas, NV, December, 1984.

Johnson, T.L. and Kaliski, M.E. "Realization of Asynchronous Finite-State Machines," 22nd IEEE Conference on Decision and Control, San Antonio, TX, December, 1983.

Johnson, T.L., "Multitask Control of
Distributed Processes," 22nd IEEE Conference on
Decision and Control, San Antonio, TX, December,
1983.

4. INTERACTIONS

Professor Kaliski and Dr. Johnson met regularly to coordinate research progress during this past year. Such meetings were on a bi-weekly basis generally.

ACM Computing Reviews
Category Numbers

5.22
5.23
7.3
3.8

Major Key Words

Automata
Hybrid System
Interfaces

Dr. Martin E. Kaliski
(presenting paper)

On Realizations of Partially-Specified Input/Output Maps by Finite Automata, MARTIN E. KALISKI,
Northeastern University, Boston, MA - Finite Automata defined over the binary alphabet $\{0,1\}$ may be viewed as realizing input/output maps from $\{0,1\}^+ \rightarrow \{0,1\}$ where $\{0,1\}^+$ is the set of all non-null strings of 0's and 1's of finite length. This study deals with an important aspect of realization: given a map $f: S \rightarrow \{0,1\}$ with S a subset of $\{0,1\}^+$, when does it have an extension F to all of $\{0,1\}^+$ which is finite state realizable? S in general is arbitrary and much of this theory generalizes to other alphabets, including the real numbers. As such it has application in asynchronous system design and microprocessor-based control.

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